Bench Mark Reset Procedures

Guidelines to preserve elevation data for a soon to be disturbed or destroyed bench mark

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UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Service
National Geodetic Survey Division

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Attached Forms:

Report on Condition of Survey Mark

Report on Relocation and Description of Reset Bench Mark

Observations for Relocation of Bench Mark

Relocating Vertical Control Bench Marks

The purpose of these guidelines is to provide the information necessary to preserve elevation data for a <u>soon</u> to be disturbed or destroyed bench mark. It is imperative that the elevation information be transferred or referenced from the original bench mark prior to its being disturbed or destroyed. The support and cooperation of local surveyors and engineers is not only important but essential to the preservation of bench marks.

Each vertical control bench mark represents a large investment of resources. Since it is intended to provide a continuous record of elevation changes, as well as control for many local surveyors, its preservation is vital. Although bench marks are constructed in locations where they are less likely to be disturbed, many are disturbed or destroyed by highway rebuilding and retrofitting, railroad maintenance, urban development, addition of buried utilities, and building demolition and construction.

If an existing U.S. Coast and Geodetic Survey (USC&GS), National Geodetic Survey (NGS), U.S. Geological Survey (USGS), or other agency bench mark residing in the NGS database (available at www.ngs.noaa.gov) is about to be disturbed or destroyed, a representative of NGS should be contacted. Points of contact for many states are listed under State Advisors on the NGS web page or found on page 7 of this documentation. Typical reset bench marks are published as third-order elevations due to the single bench mark reference to determine elevation. Refer to Attachment A for minimum requirements to maintain the order and class of the original bench mark.

There are two general situations encountered when a bench mark is to be destroyed: (1) time is available to reset a new monument in the vicinity before the threatened mark is destroyed, or (2) the mark is to be destroyed before the new mark can be set. The latter case occurs generally when the location of the new (replacement) mark is not yet suitable or available for its physical establishment. This is often the case where the new mark will not be set until a new bridge or culvert head wall is constructed. Guidelines for both cases follow.

Setting a New Bench Mark

Figure 1. Sample disk stamping.

Utilize a new NGS bench mark disk if available or your own agency bench mark disk and provide appropriate stamping. The new disk will be stamped with the same designation as the soon to be destroyed or destroyed bench mark. It will be stamped with the word RESET and the year of the reset, such as a bench mark designated M 123 that is to be reset in the year 2001 would be stamped M 123 RESET 2001.

Select a suitable site for the new bench mark, if possible within one setup from the bench mark to be replaced. Establish the bench mark as indicated on page 2 and in Attachment B of this document. Bench marks will

generally be set in a poured-in-place concrete monument, in an existing stable concrete foundation (bridge abutment), or in a drill hole in bedrock. Other types of settings are also possible and the NGS can provide guidance and other information.

Level observations between the points should satisfy third-order accuracy standards or better. Sight lengths should be limited to 70 m for this standard. Where possible, the replacement mark should be set within about 140 m of the old mark. The replacement mark should not be set farther apart than four setups, i.e., no more than 560 m apart.

Note: It is not necessary to establish the new mark at the same elevation or exact same location as the old mark.

A witness post should be set within 1 to 2 m of the relocated mark if possible. Remove any witness posts for the destroyed bench mark.

A complete description of the new mark must be provided. Descriptions should be included on the reverse side of the "Report on Relocation and Description of Reset Bench Mark" form. A sketch of the location is beneficial for comparison with the written description. Pencil rubbings or photographs of the disks confirm agency information, disk size and type, and designation stamping. Station description guidelines are available in Attachment C.

Single Mark Level Tie (3rd Order)

An assumed elevation for the old mark can be used in the leveling since the principal concern is with the **difference of elevation** between the old mark and the new one. It should be noted that the published elevation of the relocated bench mark would only be published to the nearest centimeter. This is because the absolute elevation of the bench mark to be destroyed cannot be verified without incorporating other bench marks into the survey as a check. Many projects do not provide the resources required for this multiple mark check, but it is still imperative that the mark be reset to the best precision allowable.

Precise, geodetic quality level instruments and rods should be used to transfer reset elevations to the new bench marks. The instrument and rod resolution (combined) least count should be 1.0 mm or 0.005 feet. Three-wire level instruments and rods provide checks against rod reading blunders and produce greater accuracy because averages of three readings are available. Three-wire leveling procedures are not detailed in this document.

Record rod readings to millimeters or thousandths of feet. The model and type of instrument and rods (e.g., fiberglass, aluminum, single piece, etc.) as well as rod scale units (e.g., meters, feet, or bar code) should be entered on the "Report on Relocation and Description of Reset Bench Mark" form where indicated.

Observing Sequence for Conventional Leveling

1. Remove equipment from travel cases, attach level instrument to tripod, and let equipment acclimate to local conditions. Perform instrument check (peg test) per manufacturer's instructions. Set up the instrument about halfway between the old and new bench marks, but no more than 70 m (230 ft) away from either point or from one of the points and a turning pin in the

case of multiple setup requirements. Backsight distance to foresight distance imbalance must be less than 5 meters. Accumulated backsight to foresight distance imbalance must be less than 10 meters in the case of multiple setups.

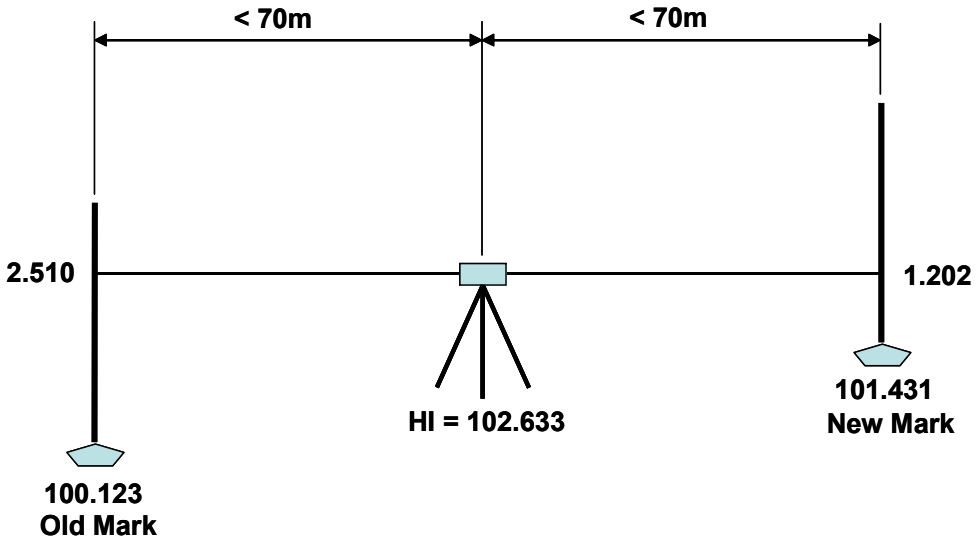


Figure 2. Direct old mark to new mark level tie. Note: Backsight-foresight distance imbalance should be less than 5 meters.

2. Plumb the level rod on the highest point of the old mark. Record the designation of the point and its published elevation noting the reference vertical datum and units of measure.

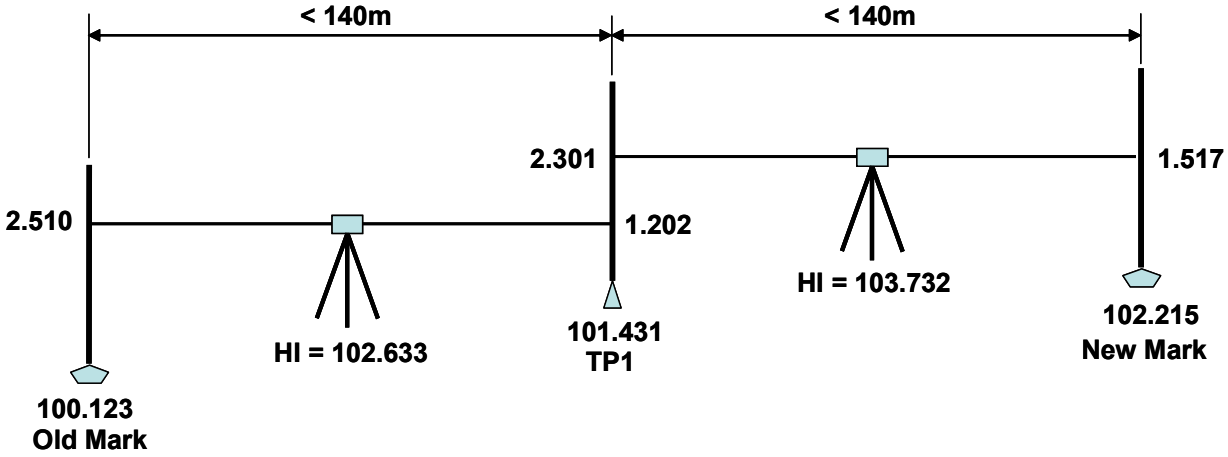


Figure 3. Old mark to new mark level tie for distances over 140 m. Note: Accumulated backsight-foresight setup imbalance should be less than 10 meters.

3. Backsight Reading: Observe the intercept of the middle reticule of the rod scale as backsight reading. Record the rod reading to the precision as indicated above. Record the stadia reading to determine distance from the point to the instrument.

4. Compute height of instrument, HI, which is the sum of the backsight and the published elevation.

5. Plumb the rod on the highest point of the new bench mark. Record the designation of the new mark, e.g., M 123 RESET, or TP1 (for turning point 1 in the case of multiple setups).

6. Foresight Reading: Observe the intercept of the middle reticule of the rod scale as foresight reading. Record the stadia reading to determine distance from the point to the instrument.

7. Compute the elevation of the new point, either the new bench mark or the turning point, which is the difference of the HI minus the foresight.

If additional setups are needed, evenly split the difference to the new bench mark with the instrument or advance no farther than 70 meters from the fore turning point and reset the instrument. Advance the back rod the same distance ahead of the instrument, within 5 meters, to the new fore turning point or to the new bench mark. Repeat steps 2 through 7 until you have reached the new bench mark.

8. For the return observations, reset and re-level the instrument even when only one turn is required. Level backward from the new point to the old, in the same manner as steps 2 through 7.

Note: The elevation computed for the old point as a result of the backward leveling for Third Order leveling may differ by no more than 1.5 mm for a single setup section or by 12*(sqrt D) from the published elevation, where D is the shortest length of section in kilometers one-way.

9. To compute the elevation difference from the old mark to the new, subtract the mean of the two elevations for the old mark from the elevation for the new mark.

Note: The old mark should not be disturbed until observations involved in the leveling have been checked by the observer or recorder.

Observing Sequence for Digital Leveling

These observing procedures are intended for use with digital levels.

1. Remove equipment from travel cases, attach level instrument to tripod, and let equipment acclimate to local conditions. Perform instrument two-peg test to determine instrument collimation error. The determined value should meet specifications and stored in the digital level as outlined in the digital level manual.

2. Set up the instrument about halfway between the old and new bench marks. Limit sight lengths to no more than 70 m (230 ft) from either point or from one of the points and a turning pin in the case of multiple setup requirements, e.g., distance between points is greater than 140 meters.

Backsight distance to foresight distance imbalance must be less than 5 meters. Accumulated backsight to foresight distance imbalance must be less than 10 meters in the case of multiple

setups. Level the instrument using the three foot screws while observing the bulls-eye bubble. Turn on instrument and select the backsight/foresight level program. Confirm that you want to start then enter the starting elevation for the old mark. Set and confirm instrument parameters, e.g., meaning 3 measurements, display maximum decimal places, record readings to onboard module, and other observing configuration information, such as rod type, and metric units.

3. Plumb the level rod on the highest point of the old mark, e.g., domed top of disk M 123. Record the designation of the point and its published elevation, noting the reference vertical datum and units of measure.

4. Backsight Reading: Point using the vertical crosshair of the level instrument on the middle of the rod over the old mark and use the focusing knob to bring the image of the rod into sharp focus Depress the measure button and record the rod reading. Note distance from rod to instrument. It should be less than 70 meters.

5. Plumb the rod on the highest point of the new bench mark. Record the designation of the new mark, e.g., M 123 RESET, or TP1 (for turning point 1 in the case of multiple setups).

6. Foresight Reading: Point and focus the level instrument on the rod over the new mark. Depress the measure button and record the rod reading. Note distance from rod to instrument. It should be less than 70 meters. Note imbalance between backsight and foresight distances. This difference should be less than 5 meters.

7. The elevation of the new bench mark or turning point is computed as the sum of the backsight reading and the published elevation minus the foresight reading.

If additional setups are needed, evenly split the difference to the new bench mark with the instrument or advance no farther than 70 meters from the fore turning point and reset the instrument. Advance the back rod the same distance ahead of the instrument, within 5 meters, to the new fore turning point or to the new bench mark. Repeat steps 2 through 7 until you have reached the new bench mark.

8. For the return observations, reset and re-level the instrument even when only one turn is required. Level backward from the new point to the old, in the same manner as steps 2 through 7. Use the elevation determined from the forward leveling as the starting elevation for the backward leveling. The elevation computed for the old point as a result of the backward leveling may differ by no more than 12*(sqrt D) from the published elevation, where D is the shortest length of section in kilometers one-way.

9. To compute the elevation difference from the old mark to the new, subtract the mean of the two elevations for the old mark from the elevation for the new mark. The elevation for the new bench mark will be this computed difference, mean of both forward and backward leveling, plus the published elevation of the old bench mark.

Note: The old mark should not be disturbed until observations involved in the leveling have been checked by the observer or recorder.

When Reference Points Are Required

If the old mark is to be removed before a new mark can be established, a series of three reference points should be set in the vicinity. The reference points should be stable points which are unlikely to move or be damaged between the time they are set and the time they are used to establish the elevation of the new mark. Examples of "stable" reference points are a chiseled cross in concrete or on outcrop, an anchor bolt, a nail driven in a tree root, stable re-bar driven in a location that will survive construction, as well as others.

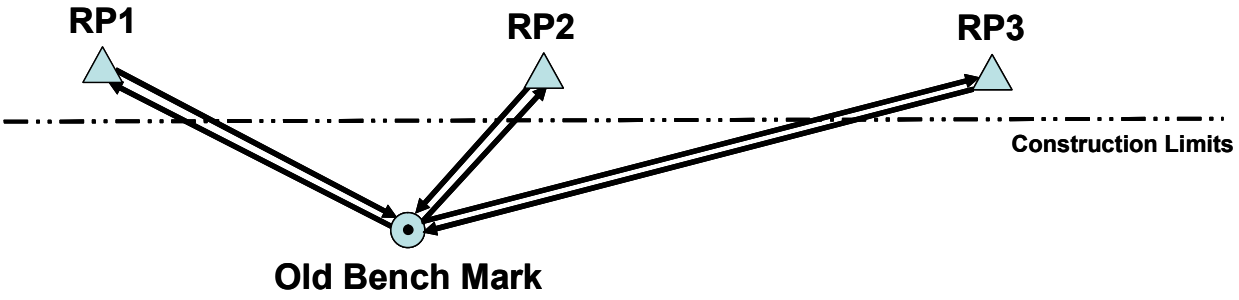


Figure 4. Old bench mark tie to three reference points.

Leveling should be performed so there is a separate setup between each reference point and the bench mark(s) following similar procedures as listed in steps 2 to 9 above. A suggested sequence is as follows: Observe forward and backward leveling between the old bench mark to be reset and reference point 1. Observe forward and backward leveling between the old bench mark to be reset and reference point 2, and observe forward and backward leveling between the old bench mark to be reset and reference point 3 as illustrated in Figure 4. The loop should be closed by observing forward and backward leveling between reference points 1 and 2 and between reference points 2 and 3 to provide an additional check on the reference points.

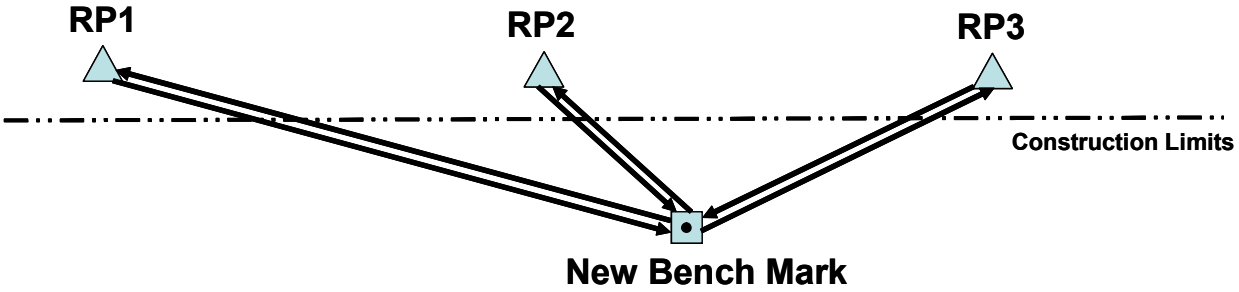


Figure 5. Three reference points tie to new reset bench mark.

A similar set of observations is obtained between each of the reference points and the new bench mark after it has been established as illustrated in Figure 5. Relative differences in elevation beyond allowable section closure tolerances should be investigated and noted.

Destroyed Bench Marks

Destroyed bench mark disks should be returned to NGS along with the reset information requested below. NGS does not remove destroyed bench marks from its records without definitive proof of the mark's destruction.

Note: If the old bench mark is in poor condition such that the elevation may be questionable, it should be considered destroyed. No effort should be made to transfer a potentially erroneous elevation to a replacement bench mark. Perform level ties to other adjacent bench marks whenever in doubt about an elevation.

After the new mark has been established and leveled to, the old disk should be removed and returned to NGS at the address listed for Data Submission. If the old disk cannot be returned, please describe the reason. A copy of the field notes, description of original mark, description of reset mark, completed reset forms, and any remarks that seem pertinent to this action should also be submitted.

Data Review and Final Adjusted Elevations

NGS will review submitted data for conformation to guidelines, quality, and completeness, then adjust observed elevation differences. Final adjusted elevation and description for the new reset mark will be published in NGS elevation records and available through its database.

Information about the National Geodetic Survey, its products and services, as well as station data sheet information can be found on the NGS Internet site at **http://www.ngs.noaa.gov**.

Data Submission

Before NGS will publish new reset elevations, the following **must be supplied**:

1. Completed "Report on Relocation and Description of Reset Bench Mark" form with new station description. (Attached form.)

2. Completed "Observations for Relocation of Bench Mark" form for observations between reset mark and existing mark(s) or reference points used to reset the mark. (Attached form.)

2a. Digital Levels: Paper as well as digital copy of leveling observations.

3. The old disk and/or "Report on Condition of Survey Mark." (Attached form.)

Bench mark resets pertaining to Montana Department of Transportation construction projects should be sent to:

Photogrammetry and Survey Section
Montana Department of Transportation
2701 Prospect Avenue
P.O. Box 201001
Helena, MT 59620-1001
Phone: 406-444-0602

Bench mark resets not pertaining to Montana Department of Transportation construction projects should be sent to:

Curt Smith
National Geodetic Survey
P.O. Box 140533
Boise, ID 83714
Phone: 208-332-7197
E-mail: Curt.Smith@noaa.gov

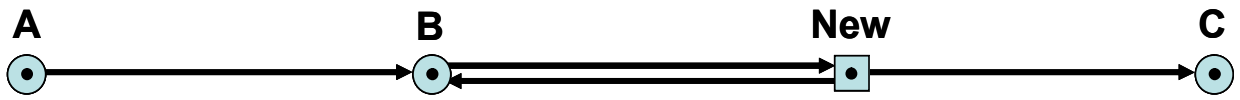
Attachment A. Guidelines and Procedures to Replace a Destroyed Bench Mark Along an Existing Level Line and Maintain Original Order of Accuracy

The guidelines and procedures given below were written to provide guidance on establishing, to the same order/class, one or two bench marks along a previously leveled line of bench marks from the remaining bench marks along that line. If a large number of bench marks in a row along a line are destroyed, it is recommended that a minimum of three existing bench marks on each side of the destroyed bench marks be tied or perhaps the entire line re-leveled.

If these guidelines and procedures are followed, the resulting height of the new bench mark will be published to millimeters, and the accuracy will be published to the same order/class as the original line. The results will NOT be published as a third-order "reset" bench mark.

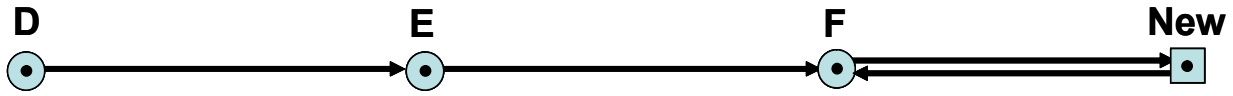
Network Geometry

First-order (preferred method): (A, B, and C are existing first-order bench marks)



A	to	B	=	single-run, must check published difference
B	to	NEW	=	double-run, forward and backward leveling must check*
NEW	to	C	=	single-run
B	to	C	=	not directly leveled but must check published difference

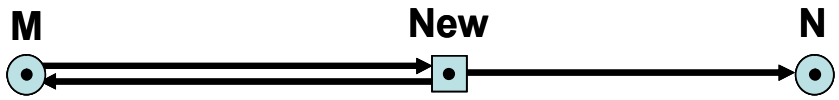
First-Order (optional method): (D, E, and F are existing first-order bench marks)



D	to	E	=	single-run, must check published difference
E	to	F	=	single-run, must check published difference
F	to	NEW	=	double-run, forward and backward leveling must check*

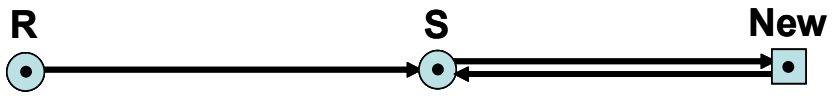
***Note:** "Check" refers to "Maximum section misclosure (mm)" of 4*(sqrt D) as defined for First Order, Class II levels, where D is shortest length of section (one-way) in km, in the publication "FGCS Standards and Specifications for Geodetic Control Networks."

<u>Second-order</u> (preferred method): (M and N are existing second-order bench marks)



M	to	NEW	=	double-run, forward and backward leveling must check*
NEW	to	N	=	single-run
M	to	N	=	not directly leveled but must check published difference

<u>Second-Order</u> (optional method): (R and S are existing second-order bench marks)



R	to	S	=	single-run, must check published difference
S	to	NEW	=	double-run, forward and backward leveling must check*

***Note:** "Check" refers to "Maximum section misclosure (mm)" of 6*(sqrt D) as defined for Second Order, Class I levels and 8*(sqrt D) as defined for Second Order, Class II levels, where D is shortest length of section (one-way) in km, in the publication "FGCS Standards and Specifications for Geodetic Control Networks."

Additional Requirements When Submitting Data to NGS

1. The observations and a description for the new bench mark and recovery notes for the existing bench marks must be submitted in Blue Book format.

2. Software programs VFPROC or PCVOBS (observations) and WDDPROC (descriptions and recovery notes) must be used to create the data in Blue Book format.

3. The monumentation should be commensurate with the monumentation used on the original level line; however, upgrading the monument to a type that will provide B or better stability is recommended.

4. The leveling equipment and procedures used must meet the FGCS specifications for the order/class of leveling being performed.

Attachment B. New or Replacement Survey Monuments

Typical bench mark or geodetic control disks are made of aluminum, brass or bronze. They are about 7.5 cm in diameter and have a domed surface to support the foot of a leveling rod and a center point for plumbing survey equipment. Information is imprinted on this surface to identify the monument and to aid the user in obtaining data on it. This pre-cast logo is recessed so that it does not interfere with the leveling rod or other survey equipment. A deformed shank or stem, about 7.0 cm long, is cast with, silver-soldered, or otherwise attached to the bottom surface of the disk to help prevent the disk from being dislodged.

Site Selection

Even though the reset bench mark must remain within the general proximity of original monument, considerations for selecting an appropriate site for the replacement monument must be addressed. Select a secure location that might provide natural protection, such as one well away from the highway surface near the edge of the right-of-way. Provide for monument stability, both vertically and horizontally, by selecting a location that reduces the influence from ground and soil movement. Avoid settings in low, potentially wet areas, in slopes, and in all earth-fill situations. Crests of hills are generally good locations for bench marks as they reduce influence of frost heave and the consistency of the soil tends to be more firm. Ensure usefulness by selecting a location that is readily accessible and safe for users. Select a site with good, unobstructed horizons so the bench mark can be used with the global positioning system if possible. ***Caution:*** **Always confirm the absence or presence and location of buried utilities prior to digging monument holes by contacting the local utility companies or diggers hot-line.**

Concrete Monuments

1. Monument Design. The concrete monument should be poured-in-place in a hole dug in the ground, cylindrical or squared in appearance and slightly "bell-shaped" at the bottom. The monument must extend well below the frost line, typically 1.3 meters deep and 0.3 meter in diameter. Local ground conditions, such as hard soil types with subsurface rock, may prohibit desired monument depth whereas softer, sandy soil types may require slightly deeper monuments to assure stability. Avoid setting concrete monuments in areas affected by sliding or other potential movement, such as in slopes and all earth-fill situations.

2. Station Designation. Stamp the station designation and setting year on the top surface of the disk prior to setting.

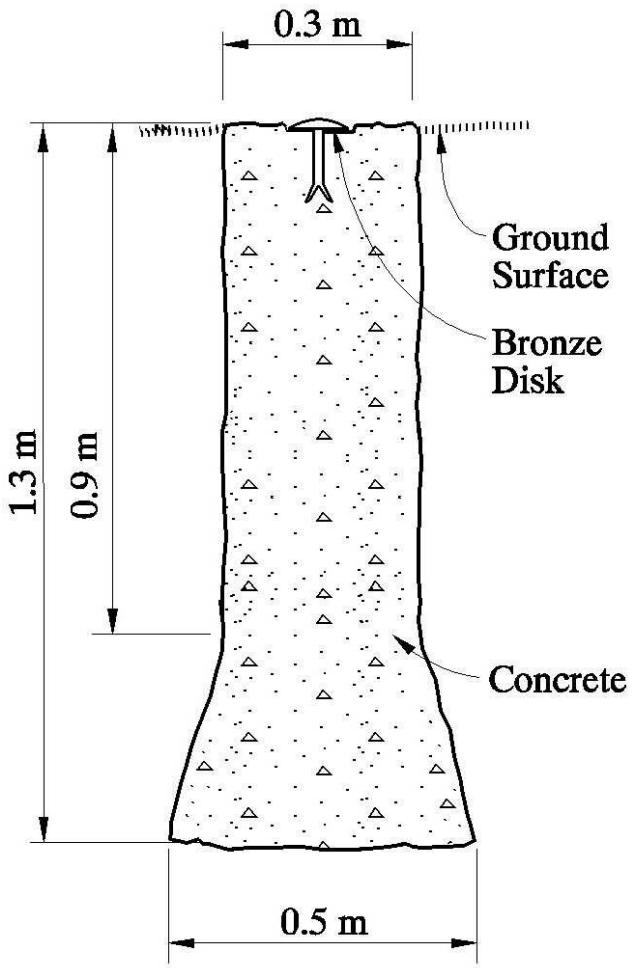
3. Digging the Hole. The hole is generally dug with an auger or post-hole digger, bell-shaped at the bottom, then backfilled with concrete mix. The bottom of the hole is enlarged about 0.1 meter in radius, tapering upward for 0.4 meter, in order to make the bottom of the monument bell-shaped. Care should be taken to avoid creating any shoulders or mushrooming effect near the top of the monument which might afford opportunity for frost heave or surface soil action. A round form is recommended, such as black tar paper (felt paper) or cardboard "sauna tube," for finishing the top 0.3 meter or so of the monument. A smooth rounded surface is less susceptible to damage by frost or other forces than unfinished tops.

4. Concrete Ingredients. The quality of the ingredients and their proportions help determine how dense and impervious the cured concrete will be. The ingredients include aggregate, cement, and water. Aggregate should be clean (free from silt and clay, harmful chemicals, and organic matter) and well graded, i.e., it contains proportionate amounts of many particle sizes. In specifying mix proportions the aggregate is usually divided into two parts, sand (particle size less than 4 mm) and gravel (particle size greater than 4 mm). Both parts should be well graded. Aggregates that are porous, split easily, or are otherwise weak or permeable result in poor concrete. Examples of poor aggregate include shale, claystone, sandstone, and micaceous rocks.

Varying sized bags of pre-mix concrete are readily available and work well for setting concrete monuments. When using pre-mix concrete, ensure that the aggregate is well graded. Additional Portland Cement and/or sand, typically ½ shovelful each per 60-pound bag, can be added to improve consistency and the quality of the finished mark. A typical concrete monument setting requires from 8 to 10 60-pound bags of concrete mix depending on the size of the hole.

The water used in concrete mix should be relatively free of impurities such as acids, alkalis, salts, oil, organic matter, and silt. These can decrease the strength and durability of cured concrete. As a rule, do not use water that you would not drink.

Figure B-1. Schematic of concrete monument.



5. Mixing and Placing. Suitable proportions (by bulk volume) of cement to sand to gravel are 1:2:3. If the gravel is made up of fragmented or angular particles, use a little less gravel and proportionately more sand. Add only enough water to make the mix workable. About half the water added to the mix is used in the chemical reaction (hydration) that causes the paste to harden into binder. If too little water is used, however, the mix will not compact properly and spaces will be left in the mass. A good indication of the right amount of water is that the mix neither runs nor falls off the shovel but sluggishly slides off and flattens upon hitting the ground.

Fresh concrete must be well mixed before it is placed, otherwise the minute particles of cement will not be sufficiently wet and the aggregate will not be completely coated with paste. Before placement, the hole should be damp so the moisture will not be drawn from the fresh concrete into the surrounding soil. In no case should it be so wet as to be muddy. Segregation of the various sizes of aggregate should not be much of a problem when pouring concrete survey monuments, but be aware that segregation can occur and is undesirable

when it does. While filling the hole, continuously tamp the mix into a compact mass so it becomes less pervious and consequently more durable. Some bleeding (water gain at the surface) is to be expected when finishing the mark. Excessive bleeding indicates too much water in the mix or poor gradation of aggregate.

6. Finishing Monument. After pouring concrete and tamping to settle and remove voids, the top of the monument is smoothed off and slightly beveled with a trowel. The top of the finished monument should be flush with the ground or slightly recessed for protection from mowers, etc. The disk is thoroughly cleaned to remove oils and extraneous dirt then set into position in the center of the monument top. Placing a small amount of concrete on the underside of the disk before installing helps insure air is not trapped under the disk. The disk is typically oriented to provide easy designation identification as you would normally approach the monument. Finish the top of the monument by smoothing with the trowel once the disk is in place.

7. Clean Up. Clean excess concrete from the surface of the disk after installing. The area is then cleaned, excess dirt and trash removed, and site returned to as-found condition. ***Caution:*** **The lime and/or cement in concrete can cause burns on skin and destroy clothing. Water used to rinse tools, concrete/cement mixing containers, etc., can kill vegetation when dumped on the ground.**

8. Curing Concrete. Concrete should normally be covered for several days after it is placed. This prevents rain from making the mix too wet and from ruining the finished surface. It also prevents the surface from drying too rapidly, leaving too little water for complete hydration.

9. Cold Weather Precautions. Freezing of fresh concrete has a damaging effect because expansion of water as it freezes separates solid particles in the mix. This reduces strength of the bond and makes the concrete more porous and correspondingly less durable. Three protective measures should be taken in cold weather, either singly or in combination. First, use warm ingredients. During the first 24 hours after a mix has been placed, it develops little heat of its own to prevent freezing. After 24 hours some heat is developed as a product of the chemical reactions occurring in the mix. The use of warm ingredients is especially beneficial during the first 24 hours. To keep the aggregate and cement warm, store them indoors and keep them in a heated vehicle until the materials are mixed.

Second, use Type III (high-early-strength) cement or special additives, such as calcium chloride, that speed curing. The calcium chloride should be dissolved in the mixing water instead of mixing it with other ingredients. If a large number of concrete marks are being installed by mass production using a “ready-mix” contractor, fast-curing additives should not be added until the concrete is delivered on site.

Third, insulate the finished mark for a week after the concrete is poured. One method is to cover the mark with boards resting on supports. This is covered with paper or plastic, then by a layer of straw, Styrofoam, or similar insulating materials about 0.15 meter thick and finally a layer of soil 0.15 to 0.3 meter thick. Pile snow loosely on top if available.

Survey Disk Set in Bedrock or Structure

Sound bedrock is the most desirable setting for vertical control points. Besides the ease and cost effectiveness with which a disk can be installed in bedrock, it provides the most stable setting in terms of both crustal motion and disturbances inflicted by people. Always use bedrock when a suitable outcrop exists. As a rule of thumb, the bedrock is considered potentially good if the distance between joints and fissures is greater than 1 meter.

1. Station Designation. Stamp the station designation and setting year on the top surface of the disk prior to setting.

2. Site Selection. Pick a fairly level and accessible spot on the outcrop that appears intact with the bulk of the rock. A simple test can be performed to help determine the condition and integrity of the rock by placing one's hand near the area the disk will be set then striking the outcrop with a moderately heavy hammer and feeling for vibration. Sound outcrop will force the hammer to rebound with each impact and vibration through the rock should be minimal.

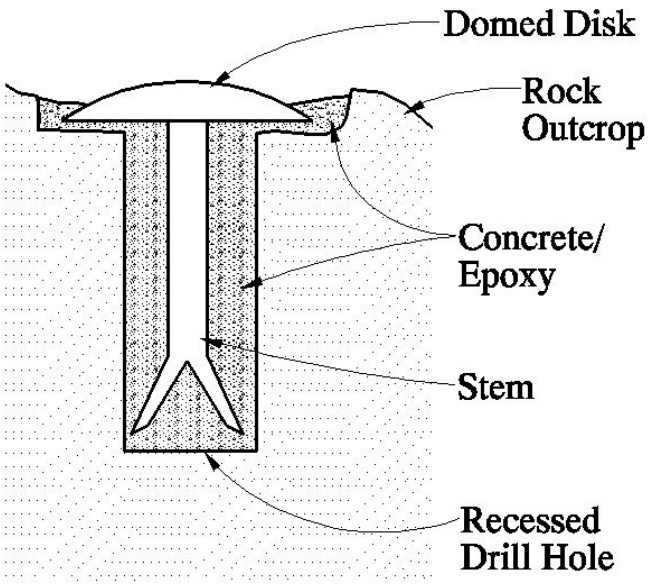


Figure B-2. Side view of disk in outcrop.

3. Drilling the Hole. Drill a 2.5 cm diameter hole about 8.0 cm deep into the bedrock. Chisel a flat, level recessed area around the top of the hole to a diameter slightly larger than the disk. Test the hole with the disk to see if it is deep enough and that the disk sits flush in the chiseled area.

When the installation is completed, the top surface of the disk should sit level and slightly below the surface of surrounding rock to help protect the disk. Chisel a drain channel through the low edge of drilled recess to allow water to drain away from finished mark. ***Caution:*** **Protective eye-wear should be worn when drilling into bedrock or masonry.**

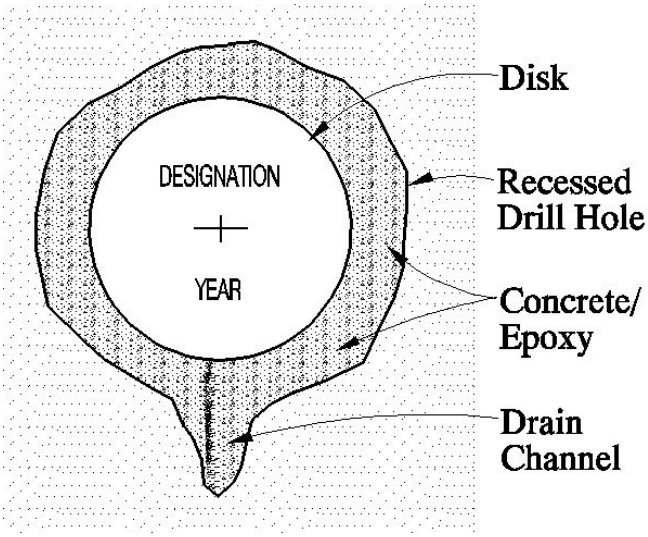
4. Mixing Cement. Remove all rock powder and debris from the hole and recessed area. Flush and fill the hole with clean water; then pour dry cement into it. Mix ingredients right in the hole with a thin stick or other implement such as a screw-driver. Add water and cement to make enough mortar/cement to fill hole with a little extra available to place on the underside of the disk. When the mortar is completely mixed, it should be thick but still workable, like heavy mashed potatoes.

5. Preparing the Disk. Wet and clean the disk by rubbing all surfaces with cement to remove unwanted dirt and oils; rinse well. Fill underside of the disk with mortar using a trowel. Hold disk loosely upside-down by the end of the shank then gently tap the domed surface of the disk from below with the handle of the trowel several times to allow mortar to settle and trapped air to

escape. This is very important because it will prevent the existence of highly undesirable voids under the disk once it's in place.

6. Setting the Disk. Place the shank of the disk into the cement filled hole and press the mark firmly into place. Slightly twist the disk back-and-forth and gently tap it with the end of the trowel handle to help settle the disk completely and evenly into the recess in the bedrock. The disk is considered set when the slight back-and-forth movement stops and the disk settles firmly in place. Work excess mortar around the outer edge of the disk, making sure that it is smooth and slightly overlaps the top, edges of the disk. An exposed disk edge could provide a weak spot used by someone or the elements to dislodge the mark.

Figure B-3. Top view of disk in outcrop.



7. Cleaning and Finishing. Sprinkle some dry cement on the exposed surface of the disk, then rub it with a clean rag or short bristled brush using circular strokes. This cleans the disk and removes excess mortar from its surface and recessed letters. Rubbing the wet mortar around the edge of the disk in the same manner is done intentionally to finish its surface and help prevent cracking. Brush away loose cement and make sure that the finished product has a neat appearance.

8. Curing Cement. Cover the newly set disk while the cement is still wet to prevent heavy rains or other foreign debris from ruining its surface and to conceal the disk from people who might tamper with it at this stage. A piece of wood, cardboard, heavy paper, or similar item should suffice and shall be removed after cement has cured.

9. Clean Up. The area is then cleaned, excess dirt and trash removed, and site returned to as-found condition. ***Caution:*** **The lime and/or cement in concrete can cause burns on skin and destroy clothing. Water used to rinse tools, concrete/cement mixing containers, etc., can kill vegetation when dumped on the ground.**

<u>Survey Disk in Structure</u>

The procedure for setting a disk horizontally in a concrete or masonry structure is identical to that for setting one in bedrock. ***Caution:*** **Use protective eye-wear when drilling into masonry or concrete.**

Stability and safety issues are also concerns when setting a disk in light structures such as bridges. Select locations with continuous, deep foundations such as head walls and avoid locations such as curbs, sidewalks, bridge decks, and railings.

When drilling into brick or other soft material, an electric drill or hammer and star drill should be used rather than heavy power equipment to prevent potential damage to the exterior. Recess the chiseled depression for the disk so that the top of the disk when set is flush with surrounding structure. This will eliminate the need for a chiseled drain as described for the disk in outcrop.

The hole should be flushed with water and wet before mortar is put into it to remove dusty surfaces and aid bonding. After placing the shank of the disk into the mortar filled hole, work it to the bottom edge of the hole, as described in Step 6, above, so that it will not settle askew while the mortar is curing.

Highway grade epoxy may be used in place of cement if it meets ultraviolet standards and will hold up to all weather conditions. The setting procedures with epoxy are similar to those described previously except that the drilled hole, though needing to be extremely clean, cannot be wet.

Attachment C. Station Descriptions

Station descriptions should be concise, accurate, informative documents that enhance recovery of survey monuments. Standardized forms for writing descriptions ensure that pertinent station information is recorded completely and consistently while at the survey monument site. This reduces errors and omissions that occur when writing station descriptions from memory. See attached "Report on Relocation and Description of Reset Bench Mark" form.

In general, descriptions are comprised of four elements: a standardized descriptive heading and three paragraphs of text including a description of physical monument, a "to reach" narrative, and permanent station reference objects with measurements therefrom.

1. Description Headings. Station description headings identify the survey monument. This heading facilitates cataloging and referencing descriptive information by the establishing agency and for others wishing to use the monument. This information includes the station designation, station identification stamping, type of monument and/or datum point, approximate latitude, longitude, elevation, and county of location, agency and date of establishment, and other pertinent data.

2. Description of Physical Monument. Text for a station description should begin with general comments consisting of a brief, approximate discussion of station site location, monument type, and setting style. This helps pinpoint the station's location on a map and assists surveyors unfamiliar with the area. General comments include airline distances and directions from nearest towns or prominent landmarks, and a general statement about immediate area, such as "on top of the east end of a long highway cut." A detailed description accurately describes the monument and prepares the surveyor for the type of monument expected at the site. Examples include: "the station is a 7.5 cm diameter brass NGS bench mark disk set in top of a 0.3 meter round concrete monument 1.3 meters deep and projecting 5.0 cm above the ground," or "the station is the top center of a stainless steel rod recessed 80 mm below ground driven to refusal at a depth of 7.5 meters encased in a 0.12 meter PVC pipe with standard logo cap surrounded by concrete and flush with the ground."

Property ownership information should be included as the last sentence for all general comment paragraphs. Ownership information, such as owner's name, address and business phone number, or a comment such as "on state highway right-of-way", facilitates station access.

3. "To Reach" Narrative. Reaching the station by vehicle or other means is described in detail in the "to reach" narrative. Begin narrative at an easily located starting reference point, such as a prominent highway junction, post office, or courthouse (sometimes post offices and courthouses are harder to find than the mark itself so judgement must be used). Direct the reader from the starting point with routes and clocked mileage, including cross-references such as road intersections, to the station site. Describe each turn, route followed and distance traveled. Vehicle mileage, accurate to the tenth of a mile, is obtained from a vehicle's odometer and directions are determined from good maps or compass headings.

Important information regarding a station's location will not be omitted if consistent writing style is maintained for all descriptions. After initial starting point of the "to reach" is described, each new sentence should be written in the following format; Go, Continue or Turn, what direction,

on what road, for what distance, to what point, e.g., “continue northwest on State Highway 22 for 2.3 km to the station on the left.”

4. Permanent Station Reference Objects with Measurements. The third and final paragraph of the station description identifies exact measurements from described reference objects.

List at least three permanent reference objects with distances and directions from the station in each description. Objects measured from varying directions to station sites are essential for locating a buried monument or to help verify that it has been disturbed or destroyed. More than three measurements and references benefit in the event that one or more are lost through time. Exact measurements to the hundredth of a meter (centimeter) and accurate compass derived directions save time when searching or digging for hidden or buried monuments.

Reference items such as numbered power poles, top center of culvert pipe ends, concrete head walls and wing walls, permanent fence corners and road center lines are long lasting and easily identified

Record all distances and measurements with proper unit annotations. If both English and metric units are desired, record one within parentheses following the other measurements, again noting associated unit annotations.

Metal or fiberglass witness posts have been set near many bench marks. If one of these witness posts is near the mark to be relocated, it should be moved or replaced, if possible, to a location near the new mark. A statement of the distance and direction from witness post to new mark should be included in description.

Report on Condition of Survey Mark

Station Name: _____

State:_____ County:_____

Agency Disk: USC&GS ___NGS USGS Other:_____

Station Recovered By:_____

Organization:_____

Address:_____

Telephone:_____ Date of Recovery:_____

Stamping on the Disk:_____
(Example: *Y 126 RESET 1982* or *JONES 1986* or *JONES NO 2 1986*)

Recovery Condition: **Good** **Poor** **Not Found** **Destroyed**
(Note: **Circle one**. Destroyed means you recovered disk and are returning it to address listed below)

Explanation of Recovery:_____

_____

Changes (if any) to the Station Description:_____

_____

_____

_____

_____

_____

_____

(Note: *RAD* = Recovered As Described; Changes example: *TO REACH THE STATION FROM THE INTERSECTION OF U.S. HIGHWAY 36 AND STATE HIGHWAY 24 IN SALEM, GO SOUTH ON U.S. HIGHWAY 36 FOR 3.5 KILOMETERS TO THE MARK ON THE LEFT. THE MARK IS 34.5 M EAST FROM THE CENTER OF THE HIGHWAY, 15.4 M SOUTH FROM A POWER POLE.* Try to give four measured ties in the description. If only a witness post or other feature is added, report only that information: *THE MARK IS 2.5 M EAST FROM A FIBERGLASS WITNESS POST*.

Return this form to: Curt Smith
National Geodetic Survey
P.O. Box 140533
Boise, ID 83714
Telephone: 208-332-7197

Include the following information if known:

NGS database PID:_____ USGS Quad:_____

Latitude:_____ Longitude:_____

Elevation:_____ Setting Type:_____

Report on Relocation of Reset Bench Mark

Station Designation:	Level Line Number:	State:	County:
Latitude:	Longitude:		Position Accuracy: +/- _____ Scaled GPS Other:
Project Name:	Highway Name:		Key#:

Information About Old Mark (circle or check options):

Exact Stamping of Old Disk: _____

Agency Pre-Cast in Disk/Monument Cover: _____

Published Elevation of Old Bench Mark: _____ Meters Feet Datum:_____

Old description agrees as found? Very well More or less Poorly Not at all

Old monument solidly in ground? Yes No, explain:_____

Any damage to disk or monument? No Yes, explain:_____

Anticipated date old mark to be Disturbed or Destroyed _____

Describe reason for reset: _____

Information About New Mark:

Exact Stamping of New Disk: _____ Date Set: _____

Agency Pre-Cast in Disk/Monument Cover: _____

Type of Disk Set: _____ Magnetic Material: _____

Site suitable for use with GPS geodetic surveying (e.g., few obstructions to satellites) Yes No Don't know

Setting Classification of New Monument (circle monument type 1, 2 or 3; circle or check options):

1. Concrete Post:
   a. Diameter of Monument: _____ m Depth of Monument: _____ m
   b. Top of Monument: Flush □ Projecting □ Recessed □ _____ m, with ground.
2. Disk Set in Drill Hole:
   a. Rock Outcrop □ or Boulder □ Approximate exposure: _____ m by _____ m
   b. Bridge Abutment □ or Other, explain: _____
   c. Mark relationship with surface: Flush □ Projecting □ Recessed □ _____ m, with _____
3. Rod Mark Driven to Refusal:
   a. Depth of rod driven: _____ m To refusal, Slow time met Grease filled sleeve depth: ____ m
   b. Top of rod recessed _____ cm below monument cover.
   c. Top of monument cover: Flush Projecting Recessed _____ m, with

Reported By: Date: _____

Agency: _____ Contact: _____

Address: _____ Telephone: ( )_____

City / State / Zip: _____ Fax: ( ) _____

E-mail: _____

Station Description
New Station Designation:
Description of Physical Location
To reach the station from

Permanent Station Reference Objects		
Distance to Mark	Direction to Mark	Description of Reference Objects

Observations for Relocation of Bench Mark

Original Mark Stamping: _____ | Replacement Mark Stamping: _____

PID (if known): _____ | Date of Leveling: _____

Elevation: _____ (ft / m) | Computed Elevation:

Vertical Datum: NGVD 29 or NAVD 88 | (from below) _____ (ft / m)

State: County: Latitude: N Longitude: W Hz. Datum:

Level Instrument: Manufacturer: _____ Model Number: _____ Serial Number: _____

Rod #1: Manufacturer: _____ Model Number: _____ Serial Number: _____ Rod Scale Units:

Rod # 2 (optional): _____ Model Number: _____ Serial Number: _____ Rod Scale Units:

Forward Running: Old to New (ft / m) Observer: Rodman # 1: Rodman # 2:

Start Time: Temperature: F / C Sun Conditions: Wind Conditions: Stop Time:

Point	Backsight	H.I.	Foresight	Elevation	Distance	Remarks
		Starting or Published Elevation =				
		Forward Running Elevation / Total Distance =				

Backward Running: New to Old (ft / m) Observer: Rodman # 1: Rodman # 2:

Start Time: Temperature: F / C Sun Conditions: Wind Conditions: Stop Time:

		Starting Elevation from Forward Running Elevation =				
		Backward Running Elevation / Total Distance =				
			Forward Starting or Published Elevation =			
			Backward Running Elevation =			
			Difference = Forward Starting or Published Elevation – Backward Running =			
Final New Elevation = Forward Running Elevation – (*Difference ÷ 2)				***Maintain Sign of Difference =**		

Agency / Firm: _____ Submitted By: _____

Address: _____ Telephone: ( ) _____

City / State / Zip: E-mail: